

## **The Zoeal Stages of *Pilumnus minutus* De Haan, 1835 (Decapoda: Brachyura: Pilumnidae) in the laboratory**

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### **ABSTRACT**

The zoeal development of the pilumnid crab, *Pilumnus minutus* De Haan, 1835 consisted of 4 zoeal stages. The duration of the zoeal stage was at least 15 days at 25°C. The morphology of the zoeal stage is described in detail, and comparisons are made with the known larvae of other species of the family pilumnidae. The *Pilumnus minutus* zoea strongly resembles zoeae of other species of the genus *Pilumnus* in the mouthpart setation and the carapace spines, but shows some differences in the abdominal lateral knobs. The *Pilumnus minutus* zoea has some affinities with the *Parapilumnus trispinosus* zoea by having the abdominal lateral knobs on somites 2, 3, 4 and 5.

Key words: Zoeal development, *Pilumnus minutus*, Pilumnidae, Korea.

### **INTRODUCTION**

The pilumnid crab, *Pilumnus minutus* inhabits the crevices of rock and roots of sea weed from littoral to 50 meters deep (Sakai, 1976). This species is known to range from the Malay Archipelago to Japan and Korea (Kim, 1973).

In the past, the pilumnid crab was regarded as a subfamily of the family Xanthidae (Balss, 1957; Sakai, 1976). But Guinot (1978) reorganized this family. Now the former Xanthidae are classified at superfamilial rank and the former Pilumnidae at familial rank. Seven species of pilumnid crab are reported in Korea: *Pilumnus longicornis*, *P. minutus*, *Heteropilumnus ciliatus*, *Actumnus asper*, *Pilumnopeus indica*, *P. makiana* and *Parapilumnus trispinosus* (see Kim, 1973; Kim & Kim, 1982).

The complete larval development of *Pilumnopeus makiana* and *Parapilumnus trispinosus* were

already described by Lee (1993) and Ko (1994), and that of *Pilumnopus indica* will be reported by Ko (unpublished). In the species of *Pilumnus minutus* and *Heteropilumnus ciliatus*, only the first zoeal stages have been described by Aikawa (1929) and Takeda and Miyake (1968). In addition, the larval stages of the *Pilumnus* have been reported in *P. dasypodus* by Sandifer (1973), *P. vespertilio* by Lim and Tan (1981), and *P. hirtellus* by Salman (1982). However, the first zoea of Aikawa's *Pilumnus minutus* was too briefly described and some differences of description are found between Aikawa's and the present study. Therefore, there is a need of detailed redescription.

In this paper all the zoeal stages of *Pilumnus minutus* are described in detail and compared with previously described larvae of the pilumnid crabs, with discussion on the phylogenetic relationship between *Pilumnus minutus* and other pilumnid species, based on the larval morphology.

## MATERIALS AND METHODS

In July, 1994, an ovigerous female of *Pilumnus minutus* was collected from amongst sponge on mud flats in Jindo Island located in the southwestern part of Korea. In the laboratory, the crab was maintained in an aquarium containing sea water (salinity 33.3‰) in the room temperature at about 25°C. When the eggs hatched, some larvae were immediately preserved in 10% neutral formalin for later examination. They were fed on *Brachionus* sp. and newly hatched *Artemia* nauplii every day. Daily, the larvae were moved into new containers with freshly filtered sea water.

Specimens and exuviae of each developmental stage were preserved in 10% neutral formalin. Drawings were made using a camera lucida. The chromatophore patterns were determined by observation of living larvae.

## RESULTS

Only four zoeal stages were recognized. A small number of the fourth zoeae failed to molt into megalopa. The descriptions of the zoeal stages are presented below. The first zoea is described completely. For the later zoea, only the main differences from the first zoea are detailed.

### First Zoea (Fig. 1)

Size. Carapace length 0.45 mm. Distance from tip of dorsal to tip of rostral spine 0.71 mm.

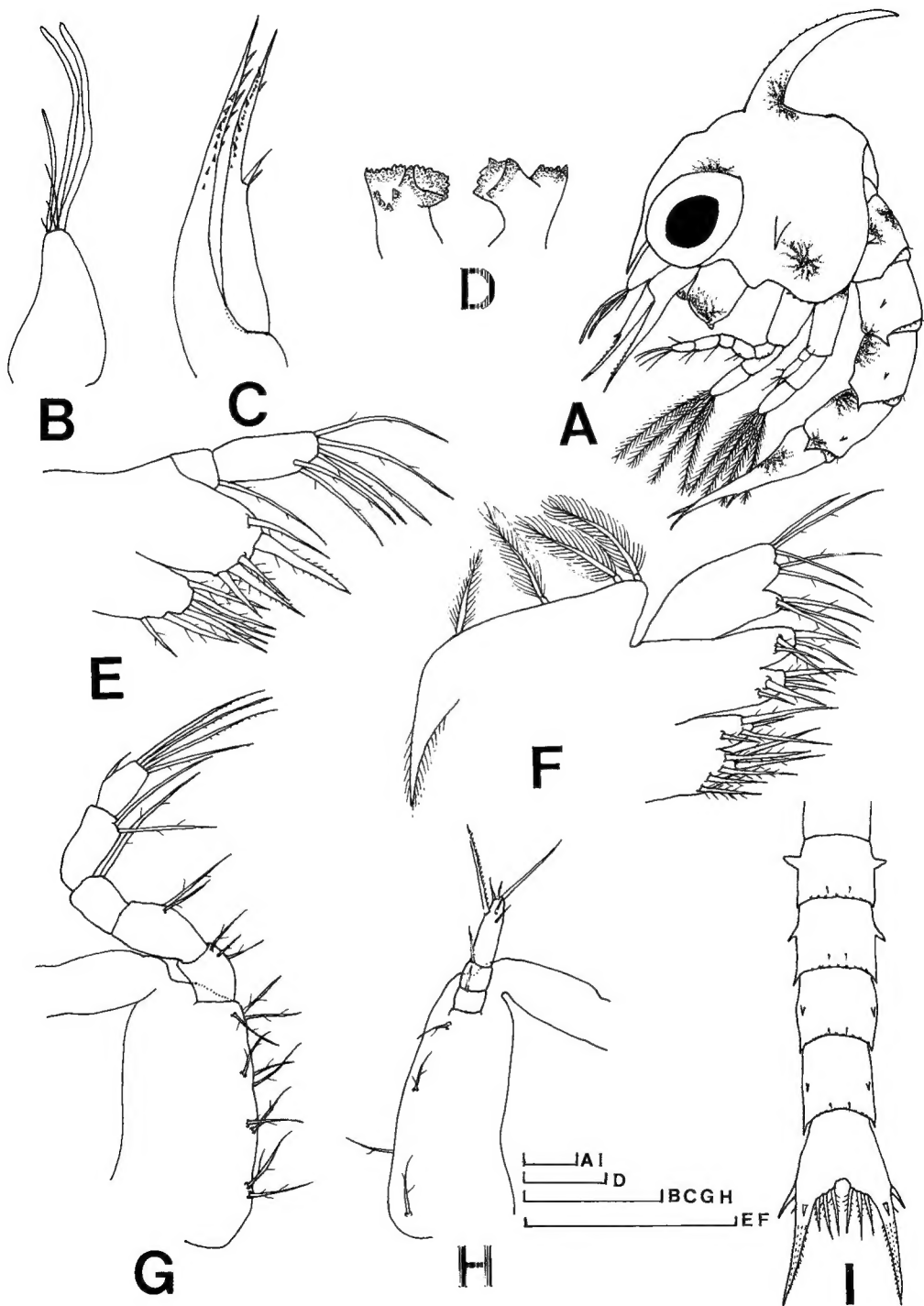
Carapace (Fig. 1A). Dorsal spine slightly curved and hook shape, with minute spinules and longer than short rostral spine. Lateral spines present.

Antennule (Fig. 1B) with 3 aesthetascs and 3 simple setae (1 large and 2 small).

Antenna (Fig. 1C). Exopod slightly shorter than spinous process and with 2 medial spines.

Mandibles (Fig. 1D) asymmetrical. Right molar process with 4 teeth which is confluent with incisor process. Right and left molar processes irregularly dentate.

Maxillule (Fig. 1E). Endopod 2-segmented; distal segment with 4 terminal and 2 subterminal plumodenticulate setae; proximal segment with one plumodenticulate seta. Basal and coxal endites each with 5 and 7 plumodenticulate setae, respectively.



**Fig. 1.** *Pilumnus minutus*, first zoeal stage. A, lateral view; B, antennule; C, antenna; D, mandibles; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, dorsal view of abdomen and telson. Scale bars = 0.1 mm.

Maxilla (Fig. 1F). Endopod 2-lobed, with 5 and 3 plumodenticulate setae. Basal and coxal endites each with 9 and 10 plumodenticulate setae, respectively. Scaphognathite bearing 4 marginal plumose setae and a terminal process.

First maxilliped (Fig. 1A, G). Basis with 2, 2, 3, 3 plumodenticulate setae, endopod 5-segmented with 3, 2, 1, 2 and 1+4 plumodenticulate setae, segments increasing in length distally. Exopod with 4 plumose natatory setae.

Second maxilliped (Fig. 1A, H). Basis with 4 plumodenticulate setae. Endopod 3-segmented with 1, 1 and 6 plumodenticulate setae, segments increasing in length distally. Exopod with 4 plumose natatory setae.

Abdomen (Fig. 1A, I) with 5 somites; somite 1 naked, somites 2-5 each with lateral knobs decreasing in size to telson and each with a pair of fine short setae on postero-dorsal border.

Telson (Fig. 1A, I) with 3 setae (long lateral, short lateral and short dorsal) on each side at base of forca. Forcal surface covered with minute spinules. Inner posterior margin of telson with 3 pairs of denticulate setae.

Chromatophores (Fig. 1A) predominantly brown, but ranging from dark brown or almost black to pale brown and yellow with variable red pigment. These occur on bases of labrum and mandible, behind eyes, on abdominal somites 1-4 and telson, on marginal expansion of carapace, on basis of second maxilliped and at base of dorsal spine.

### **Second Zoea (Fig. 2)**

Size. Carapace length 0.54 mm. Distance between tip of dorsal to tip of rostral spine 0.86 mm.

Carapace (Fig. 2A) with 2 plumose setae on postero-lateral border.

Antennule (Fig. 2B) with 4 aesthetascs and 2 simple setae (1 large and 1 small).

Antenna (Fig. 2C) with an endopod bud.

Maxillule (Fig. 2D). Basal endite with 8 plumodenticulate setae; coxal unchanged. Distal-lateral margin with a plumose seta and a plumodenticulate seta.

Maxilla (Fig. 2E). Basal endite with 10 plumodenticulate setae; coxal unchanged. Scaphognathite with 8 marginal and 3 terminal plumose setae.

First and second maxillipeds (Fig. 2A). Setation of basis and endopod unchanged. Exopod with 6 plumose natatory setae.

Abdomen and telson (Fig. 2A, F). First somite with a dorsal seta. Inner posterior margin of telson with 4 pairs of denticulate setae (3 large and 1 short).

### **Third Zoea (Fig. 3)**

Size. Carapace length 0.59 mm. Distance between tip of dorsal to tip of rostral spine 1.00 mm.

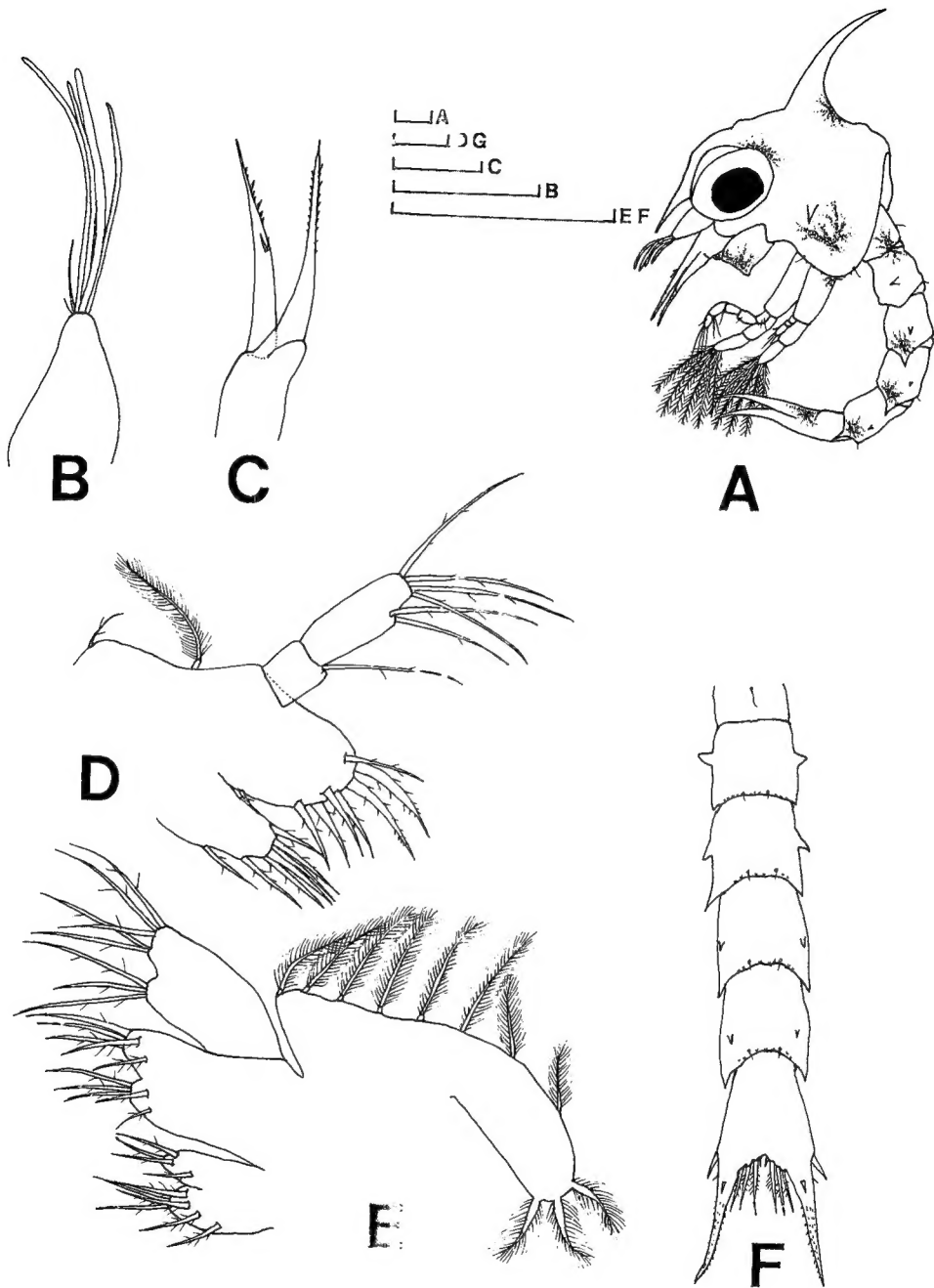
Carapace (Fig. 3A) with 3 plumose setae on postero-lateral carapace border. Buds of thoracic appendages visible through carapace.

Antennule (Fig. 3B) with 3 aesthetascs and a seta terminally, a small aesthetasc subterminally.

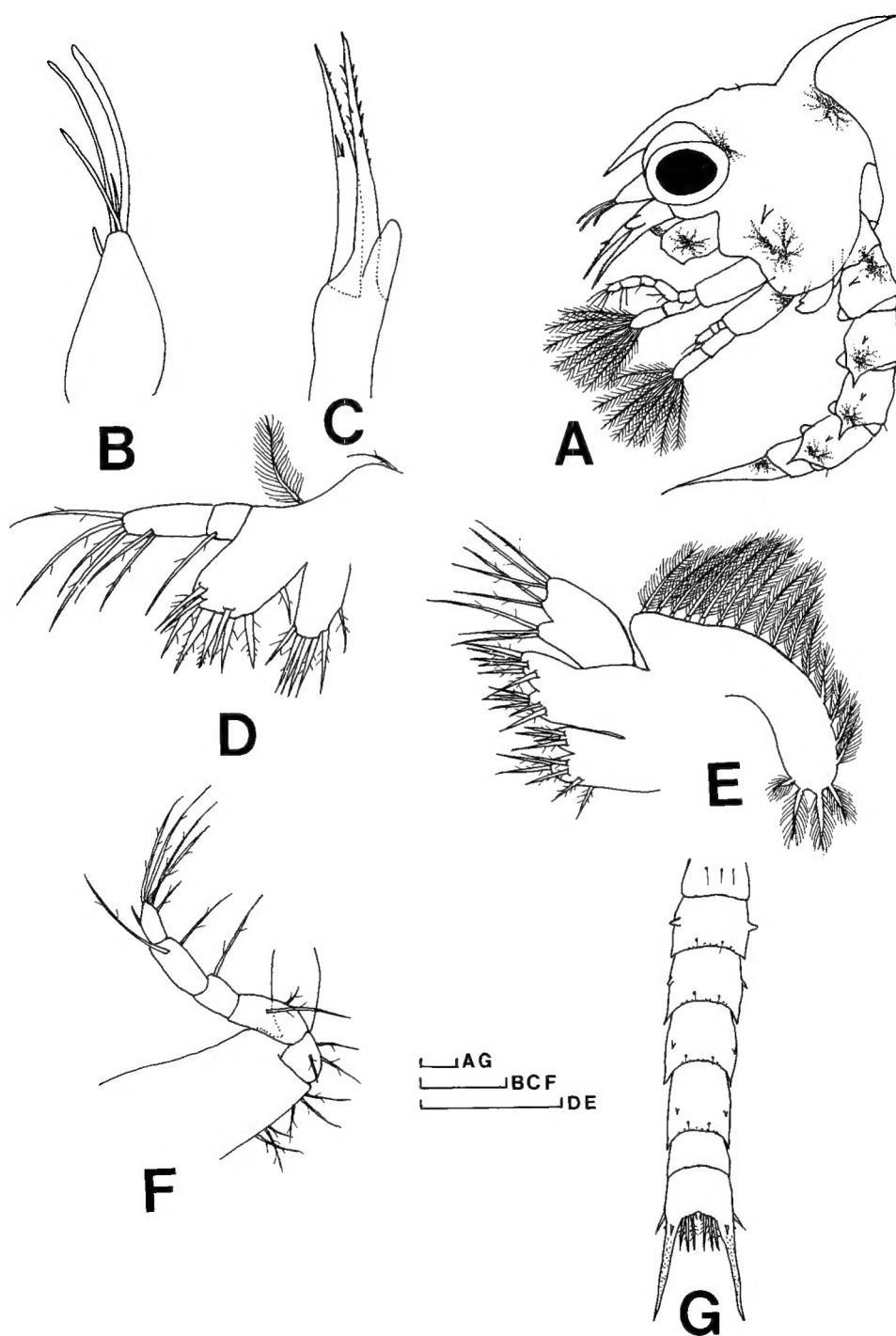
Antenna (Fig. 3C). Endopod bud more developed than that of previous stage.

Maxillule (Fig. 3D). Basal endite with 9 plumodenticulate setae; coxal unchanged.

Maxilla (Fig. 3E). Basal endite with 12 plumodenticulate setae; coxal unchanged. Scaphognathite with 19 plumose setae.



**Fig. 2.** *Pilumnus minutus*, second zoeal stage. A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, dorsal view of abdomen and telson. Scale bars = 0.1 mm.



**Fig. 3.** *Pilumnus minutus*, third zoeal stage. A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, endopod of first maxilliped; G, dorsal view of abdomen and telson. Scale bars = 0.1 mm.

First maxilliped (Fig. 3A, F). Endopod with 3, 2, 1, 2 and 1+ 5 plumodenticulate setae. Exopod with 8 plumose natatory setae.

Second maxilliped (Fig. 3A). Setation of basis and endopod unchanged. Exopod with 8 plumose natatory setae.

Abdomen (Fig. 3I). Abdomen composed of 6 somites: first somite with 3 dorsal setae, somites 2-6 with pleopod buds.

#### Fourth Zoea (Fig. 4)

Size. Carapace length 0.77 mm. Distance between tip of dorsal to tip of rostral spine 1.18 mm.

Carapace (Fig. 4A). Thoracic appendages more developed than that of previous stage.

Antennule (Fig. 4B) with 9 aesthetascs and a terminal seta. Endopod bud present.

Antenna (Fig. 4C) with a well developed endopod.

Maxillule (Fig. 4D). Basal endite with 11 plumodenticulate setae.

Maxilla (Fig. 4E). Basal and coxal endites unchanged. Scaphognathite with 21 plumose setae.

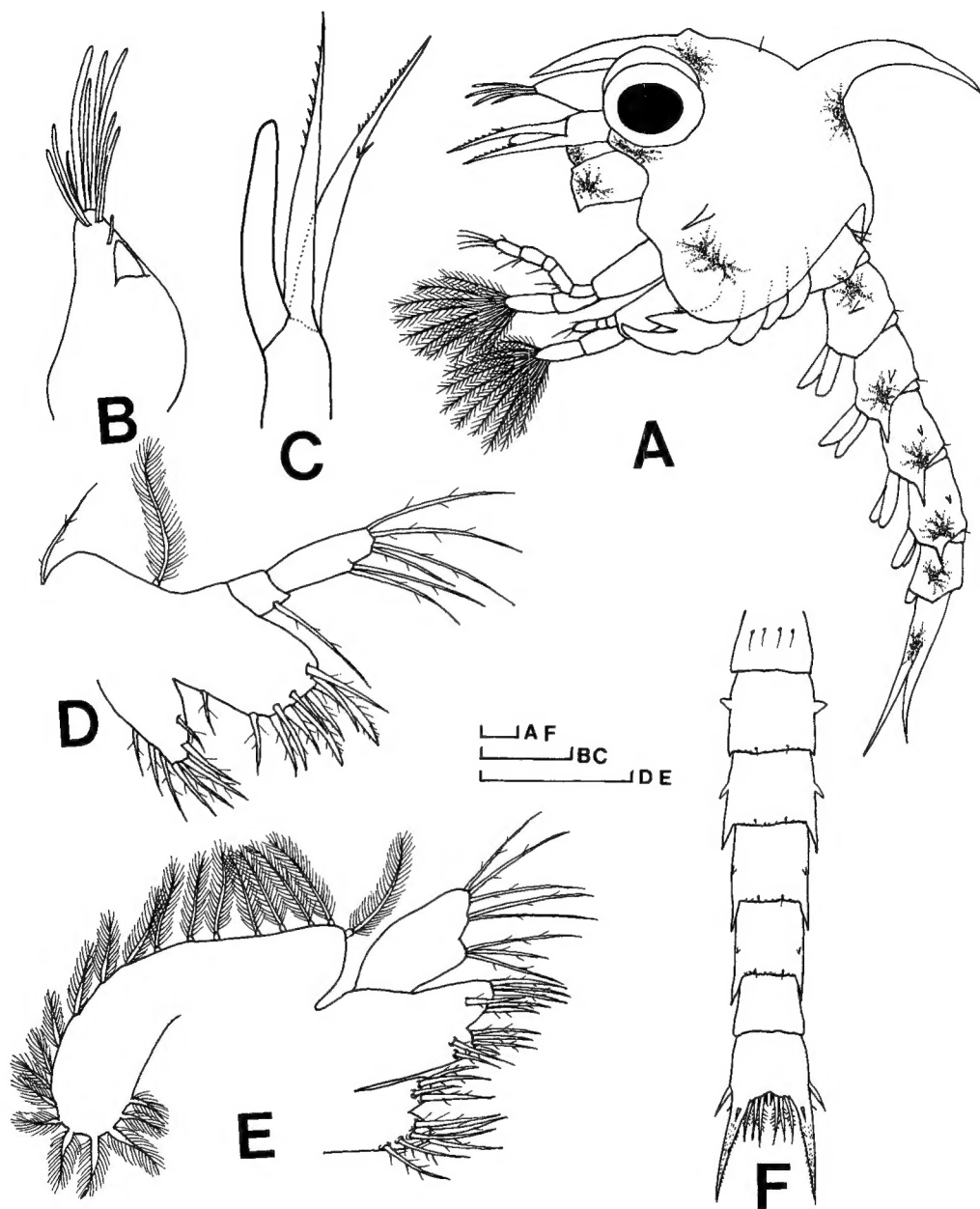
First and second maxillipeds (Fig. 4A). Endopod setation unchanged. Exopod with 10 plumose natatory setae.

Abdomen (Fig. 4A, I). First somite with 4 dorsal setae. Pleopod buds larger than that of previous stage.

## DISCUSSION

Although Aikawa (1929) first reported the first zoea of *Pilumnus minutus*, his description about the zoeal appendages was too brief. Moreover, some features of the first zoea reared in the present study somewhat differ from those of Aikawa (table 1). Such morphological differences may resulted from a lack of detailed examination.

The Pilumnidae zoeae strongly resemble zoeae of the Xanthidae in mouthpart setation, but they are much more variable than generally found in the Xanthidae in other features such as carapace spine and lateral knobs on the abdominal somites: the dorsal carapace spines are long and straight, slightly curved or hook shape; the rostral spines are long, short or vestigial; the lateral spines are present or absent; the abdominal lateral knobs are on somite 2 and occasionally somites 3, 4 and 5. Therefore, I (Ko, 1994) previously suggested the five groups of Pilumnidae zoeae in the characteristics of the carapace spines and abdominal lateral knobs: (1) the genera *Heteropanope* and *Heteropilumnus*, (2) the genera *Actumnus* and *Pilumnus*, (3) *Pilumnopeus makiana* and *P. serritifrons*, (4) *Parapilumnus trispinosus*, and (5) *Pilumnopeus eucratoides* and *P. indica*. The genus *Pilumnus* zoeae, *P. dasypodus* by Sandifer (1973), *P. vespertilio* by Lim & Tan (1981) and *P. hirtellus* by Salman (1982), always have a hook-like or slightly curved dorsal spine, a short rostral spine, the presence of lateral spines and the abdominal lateral knobs on somites 2 and 3. Hence, the *Pilumnus* zoeae has been recognized as a very uniform group within the Pilumnidae. But the present species *P. minutus* unusually have the abdominal lateral knobs on somites 2, 3, 4 and 5. This feature could be found only in the *Parapilumnus trispinosus* zoea, therefore, it should be considered as the *Pilumnus minutus* zoea has some affinities with the *Parapilumnus trispinosus* zoea (table 2).



**Fig. 4.** *Pilumnus minutus*, fourth zoeal stage. A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, dorsal view of abdomen and telson. Scale bars = 0.1 mm.

Moreover, these characteristics, the presence of lateral spine and the abdominal lateral knobs on somites 2, 3, 4 and 5, may be used as an aid for the identification of the *Pilumnus minutus* zoeae amongst Pilumnidae zoeae by planktologists.



**Table 1.** Comparison of the characteristics of the first zoeae of Aikawa's (1929) *Pilumnus minutus* with those obtained in the present study.

	Aikawa (1929)	Present study
Carapace		
Dorsal spine	no description	minute spinules
Antennule	2 aesthetascs, 3 hairs	3 aesthetascs, 3 setae
Maxillule		
Basal endite	no description	5 setae
Coxal endite	no description	7 setae
Maxilla		
Basal endite	no description	9 setae
Coxal endite	no description	10 setae
Abdomen		
Lateral knobs	somites 3, 4	somites 2, 3, 4, 5
Telson		
Outer setae	2 setae	3 setae
Surface of forcae	no description	minute spinules

**Table 2.** Morphological features of the first zoeae of 5 species of the Pilumnidae.

Species (Authors)	<i>Pilumnopeus</i> <i>makiana</i> (Lee, 1993)	<i>Pilumnopeus</i> <i>indica</i> (Ko, unpublished)	<i>Heteropilumnus</i> <i>ciliatus</i> (Takeda & Miyake, 1968)	<i>Parapilumnus</i> <i>trispinosus</i> (Ko, 1994)	<i>Pilumnus</i> <i>minutus</i> (Present study)
Carapace					
dorsal spine	straight	hooked	straight	slightly curved	hooked
rostral spine	long	short	long	short	short
Maxillule					
setae of coxis	5	7	no description	7	7
Maxilla					
setae of endopod	7	8	8	8	8
setae of coxis	9	10	8	10	10
Maxilliped 2					
setae of endopod	1,1,5	1,1,6	1,1,5	1,1,6	1,1,6
Abdomen					
lateral knobs	somites 2,3	somite 2	somites 2,3	somites 2,3,4,5	somites 2,3,4,5

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## 애기털보부채게(갑각강, 단미목, Pilumnidae)의 zoea 유생

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### 요 약

실험실에서 사육된 애기털보부채게의 유생은 4 zoea 유생기를 가졌고, zoea 유생기를 완료하는데 25°C 수온에서 최저 15일이 걸렸다. 각 zoea 유생기의 형태적 특징을 상세히 기록, 도시하고 Pilumnidae과의 이미 보고된 다른종의 제 1 zoea 유생과 그 특징을 비교하였다. 애기털보부채게는 구부부속지나 갑각극의 형태적 특징에서 *Pilumnus* 속의 다른 종들과 차이가 없었으나 복부측돌기는 복부 제 2, 3, 4, 5절에 존재하므로 *Pilumnus* 속의 다른 종들과 형태적 차이를 보이고, 이 특징은 세가지부채게에서 볼수있는 복부의 형태적 특징으로 두종간에 어떤 유연관계가 있는 것 같다.